DOCUMENT RESUME

ED 161 840 SP 013 215

| | |
|---|---|
| AUTHOR | Liemohn, Wendell |
| TITLE | Hamstring Injuries--An Examination of Possible Causes. |
| SPONS AGENCY | National Institutes of Health (DHEW), Bethesda, Md. |
| PUB DATE | Apr 78 |
| GRANT | PHS S07 RR7031-77 |
| NOTE | 16p.; Paper presented at American Alliance for Health, Physical Education, and Recreation Convention (Kansas City, Missouri, April 11, 1978) |
| EDRS PRICE | MF-$0.83 HC-$1.67 Plus Postage. |
| DESCRIPTORS | *Athletes; Biomechanics; Human Body; *Injuries; Motor Development; *Physical Education; Physical Sciences; *Running; *Track and Field |
| IDENTIFIERS | *Hamstring |

ABSTRACT

On the basis of research, the following characteristics appear to be important factors relative to precluding hamstring strains in sprinters: bilaterality relative to hamstring and quadricep strength development, optimum strength ratios between ipsilateral antagonists throughout the range of movement, and above-normal hip-joint flexibility. (JD)

KAMSTRING INJURIES --- AN EXAMINATION

OF POSSIBLE CAUSES



*Wendell Liemohn

Indiana University



A paper presented at the American Alliance for Health, Physical Education, and Recreation Convention, Kansas City, April 11, 1978,

This research was supported by National Institutes of Health Grant, PHS S07 RR7031-77.

*Now affiliated with The University of Tennessee - Knoxville.

Although hamstring strains have been an enigma to coaches and athletes for years, little has been done to elucidate the causes of this relatively prevalent injury. Burkett (1970), utilizing Clarke's (1966) cable tensiometer strength measurement procedures, found a greater susceptibility to hamstring strains if one had either a strength imbalance of 10 percent or more between the hamstrings, or had what he called an "inappropriate" flexor-extensor (i.e., hamstring-quadricep) strength ratio. Klein and Allman (1969) believe that a .60 ratio for thigh flexor-extensor strength lowers the incidence of knee injuries in football players; however, the ideal strength ratio may not be known for all athletes. Klafs and Arnheim (1973) are of the opinion that inflexibility is a precipitator of hamstring strains; however, Burkett (1970) did not find this to be a significant factor when flexibility was measured by the Well's Sit-and-Reach Test.

The aforementioned tenets/findings precipitated the initial research done by the author (1976, 1978) in this area; the subjects were 27 Indiana University (IU) track athletes (10 sprinters, 5 hurdlers, 6 long and/or triple jumpers, and 6 pole vaulters). In addition to following Clarke's (1966) strength measuring procedures for determining hamstring and quadricep strength, quadricep strength was also measured with the knee-joint at 165°. With the feet fixed while extension is taking place at the knee-joint, the hamstrings' action changes from stabilizing-flexion to active extension. Carlsöö and Molbech (1966) found that the timing of this paradoxical extensor action might vary between individuals. Slocum and James (1968) believe that its timing might be related to hamstring strains. In light of the aforementioned and because the author was of the opinion that many of our weight training regimens favored quadricep development more so than hamstring development, measurement of quadricep strength at 165° seemed warranted. Because it is plausible to expect

bilateral imbalance with respect to hip-joint flexibility due to the unilateral requirements of some of the activities in which track athletes perform, unilateral hip-joint flexibility measurements were made with a goniometer utilizing the procedure outlined in International Standard Orthopaedic Measurements (1963). Subsequent to the data collection 7 track athletes sustained mild to moderate hamstring strains. The findings of this initial study included: (1) most athletes tended to have greater right leg flexor-extensor strength composites than left, (2) many of the athletes were bilaterally imbalanced relative to strength and flexibility, and (3) the three sprinters sustaining hamstring strains from this group were less flexible and less bilateral relative to flexibility than the 7 non-injured sprinters.

There are other factors too which may also have a bearing on hamstring strain incidence. Slocum and Bowerman (1962) are of the opinion that pelvic position is the key to postural control in running, for pelvic tilt controls the amount of lordotic curve in the lumbar spine. Slocum and Bowerman noted that the smaller the lordotic curve is, the greater is the ability to externally rotate the thigh and flex the femur at the hip-joint. Allan Ryan, M. D., editor of the Physician and Sportsmedicine, believes that too much anterior pelvic tilt (this would be a concomitant of an increased lordotic curve) may be a precipitator of hamstring strains because of the increased muscular tension resulting from exaggerated posterior displacement of the ischial tuberosities (1976). Sam Bell, a 1976 Olympic track coach and the coach of Indiana University's track team, is of the opinion that hamstring strains for 100 meter sprinters frequently occur in the middle third of the race, i.e., sometime after acceleration is completed but yet usually before the last few meters (1976). Quite possibly at this point the sprinters may be pressing and/or stretching to keep and/or improve their positions. If one would attempt to gain speed by

increasing stride length (e.g., stretching), forward and backward oscillation of the pelvis might be magnified. This would necessitate greater hamstring effort to bring the foot downward and backward to gain speed, and hence greater stress would be placed on the hamstrings. Although some sprinters might run with too much anterior pelvic tilt, intermittent increases could logically be a concomitant effect of "pressing" or "stretching" as any sprinter attempts to stay in the race. Unfortunately this hypothesis can be best tested only under the stress of competition. Jones (1970) has hypothesized that extension at the knee before the leg has reached its most forward excursion will place the hamstrings on a hazardous stretch. Although Jones' hypothesis might be tested in other than meet conditions, it would seem that its underlying rationale might also be related to the pressing and/or stretching best seen under competitive conditions.

The purpose of this study was to attempt further elucidation of the precipitators of hamstring strains in university sprinters. Sprinters were chosen as subjects because the data collected on the 1975 IU sprinters appeared to be less contaminated by event-related idiosyncracies than the data of other track athletes. In the initial study the take-off leg, lead leg, etc., appeared to be responsible for bilaterality imbalance with respect to strength and flexibility in long jumpers, pole vaulters, and hurdlers.

METHOD

Demographic, strength, flexibility, and anthropemetric data were collected on nine IU sprinters in January and February, 1977. The demographic variables are listed in the appendix; the strength and flexibility measuring techniques were described previously (see above). The anthropometric data were collected following a procedure suggested by Sills (1976). To obviate extremes in scores and to facilitate comparisons, the strength and anthropometric data were

converted to ratios.

Five of the 9 sprinters on the 1977 IU track team sustained mild to moderate hamstring strains prior to the end of the season and subsequent to the non-cinematographic data collection. The American Medical Association (1966) defined a mild strain as a slightly pulled muscle and a moderate strain as a moderately pulled muscle. To put this in a time perspective, the athletes who sustained mild strains were competing within one month; those sustaining moderate strains were out of competition one month or longer. The strength and flexibility data available on the 10 sprinters of the 1975 IU track team were also used in the comparisons. None of the 1975 sprinters were on the 1977 IU track team.

In May, 1977, four sprinters were available for filming in practice on the day scheduled; these four men also comprised the 400 meter relay team. Two of these sprinters had sustained mild strains subsequent to the January data collection but had fully recovered prior to the May filmings. The filming was done with two Locam cameras facing each other at a point 106 feet from the finish line; the camera speed was 200 ft/sec. In practice the sprinters simulated a 100 meter dash while running in pairs; in the Tennessee dual meet 5 days later, each was filmed whenever he passed in front of the cameras in his respective races. In the meet two of the sprinters were filmed while competing in the 100 and 200 meter dashes; one was filmed while anchoring the 400 meter relay. The latter and the one remaining sprinter were filmed while running the open 400 meters and their respective legs on the 1600 meter relay.

To the investigator the more germane information on the film included pelvic tilt at foot-strike, at push-off, and at a point in between. Pelvic tilt, was determined by projecting the desired film frame on a digitizer; the latter is essentially an electronic grid which inputs raw data to a computer. For

each angle that was examined on every runner, a stylus was placed on the appropriate body landmark (e.g., greater trochanter, anterior-superior iliac spine). Because it was not feasible to mark these landmarks on the sprinters, and because the landmarks are at times difficult to pinpoint on the film, this procedure was repeated 20 times for each measurement. These 20 sets of coordinate data were used to determine the angle of pelvic tilt 20 times; the 5 highest and 5 lowest angles computed were then dropped and the mean of the remaining 10 angles was used in the analysis. Stride length and velocity were also determined and they, along with select anthropometric data, serve as marker variables.

RESULTS

1. Strength Ratios

The contralateral strength ratios are presented in Table 1. When quadricep extension strength was measured at 115°, all groups exhibited comparable bilaterality and all groups tended to have stronger right quadricep strength than left. When hamstring flexion ratios were determined, the right hamstrings were stronger than the left. However, the non-injured sprinters were more bilateral (1.028 ratio) than the mild-moderate and moderate injured groups (ratios of 1.062 & 1.088, respectively).

All groups tended to have greater left than right quadricep extension strength when the measurement was made at 165°; in these comparisons the non-injured were the most bilateral (.98 ratio) and the moderately injured were the least bilateral (.87 ratio).

When ipsilateral strength ratios were computed (Table 2), those that experienced moderate strains were disproportionately stronger in the quadriceps than the hamstrings in comparison to the other two groups. The ratio for the moderately injured was .61 right and .57 left; and it was .79 right and .76

left for the mild-moderately injured. For the non-injured the ratio was .72 for both right and the left comparisons.

In Table 3 are presented the ipsilateral strength ratios for the quadriceps and hamstrings when both measurements are made with the knee-joint at an angle of 165°. It was noted that the ratios of those who received moderate strains were somewhat lower than the ratios of those who did not experience hamstring injury (i.e., 1.10 left and 1.38 right, 1.48 left and 1.55 right, respectively).

2. Flexibility

The data relative to hip-joint flexibility are presented in Table 4. Although those sprinters who had sustained hamstring strains were slightly more bilateral with respect to flexibility, they were decidedly less flexible than the non-injured. The non-injured averaged 92 degrees for hip-joint flexibility; those that had sustained mild-moderate strains and moderate strains averaged 87 and 82 degrees, respectively.

3. Anthropometric Ratios

These data are presented in Table 5. All groups were basically comparable. In addition to computing other ratios, select breadth, circumference, and skin fold measurements were made also; these data as well did not suggest causal relationships.

4. Kinematic Data

Pelvic tilt was measured as being the angle formed by (1) a line through the greater trochanter and the anterior superior iliac spine, and (2) this line's juncture with the vertical. This is not pelvic tilt per se; however, by necessity it was used for comparative purposes in this study. In Table 6 pelvic tilt (PT) is given at push-off, when the tibia is vertic l (in forward swing phase) and at foot-strike. Practice performance was shaded on meet performance for comparative purposes. Two sets of meet data are depicted for

sprinter TH. It was done this way because TH's film performance includes both the 400 meters and the 100 meters. As seen in Table 6, there was decidedly less pelvic tilt in one of the non-injured sprinters (i.e., TP). However, the differences seen between the other non-injured sprinter and the injured ones were less definitive. Stride length and velocity are presented as marker variables in this table; additional anthropometric measurements are provided as marker variables in Table 7.

5. Other Observations.

Eight of the nine strains were to hamstrings of the left leg; in addition to having a moderate strain in his left leg, one sprinter also had a mild strain in his right leg. Five of the subjects had a prior history of hamstring strains; two of these had bilateral strains, two had left hamstring strains, and one had a right hamstring strain.

## DISCUSSION

It is possible to draw inferences from several of the strength ratio comparisons. Although the respective quadricep extension strength ratios at 115 degrees differed little, two points can be made relative to the hamstring flexion strength ratios. First, all groups tended to have stronger right hanstrings than left; this was also noted in the 1976 study. Second, the non-injured sprinters were more bilateral relative to hamstring flexion strength. The moderately injured sprinters approximated the 10 percent imbalance difference cited by Burkett (1970) as being a significant precipitator of hamstring strains.

When quadricep extension strength was measured at 165 degrees, the non-injured were again the most bilateral. The imbalance exhibited by the three sprinters sustaining moderate strains favored the left quadriceps. Examination of the ipsilateral strength ratios (again with the quadriceps extension

at 165 degrees, Table 3) magnifies this disparity. The data indicate that the sprinters sustaining moderate hamstring strains had disproportionately weak left hamstrings when the latter were compared with the strength of the left quadriceps at a knee-joint angle of 165 degrees.

Similar differences were noticed for the ipsilateral strength ratios based on conventional measurement angles (Table 2). Those sprinters that sustained moderate strains had proportionately stronger quadriceps than the non-injured. However, the formers' hamstring/quadricep strength ratio approximated the .60 suggested by Klein and Allman (1969). Nevertheless, this figure was still lower than that seen in the non-injured sprinters. The hamstring/quadricep strength ratio of the latter averaged .72. Surprisingly, the ratio of those sustaining mild strains was .77.

The data relative to hip-joint flexibility also indicates a marked difference between those who had experienced moderate strains and the non-injured. Kendall et al. (1971) state that 80-85 degrees is the normal hip-joint flexibility range; those that sustained moderate strains were within these norms. However, since the non-injured averaged 92 degrees of hip-joint flexibility, it would appear that sprinters might benefit from having hip-joint flexibility approximately 10 degrees in excess of what Kendall calls normal.

The anthropometric data do not appear to delineate precipitators of hamstring strains. Although the kinematic data present differences, it is difficult to make definitive inferences. Unfortunately it was not possible to film sprinter TP while he was running his leg on the 4 X 100 meter relay in competition; this particular sprinter's pelvic tilt was very low in comparison to that of the other sprinters. Furthermore, although sprinter TH was filmed while anchoring the 4 X 100 meter relay, he did not attain the velocity observed in his practice filming.

The kinematic data on sprinters JM and TG provide contrasts even though both had experienced comparable strains of the left hamstrings. Sprinter JM always had less pelvic tilt than sprinter TG; however, his stride and velocity were also slightly less. At push-off and foot-strike sprinter JM's pelvic tilt was higher in competition than it was in practice. Conversely, sprinter TG's pelvic tilt at the same two points was higher in practice than in competition. Although repeated measures were made of the film frames in an attempt to improve the reliability of somewhat less than optimum measuring conditions, it is possible that the data do not depict the sprinters' pelvic tilt with the accuracy desired. It is also possible that sprinters manifest gross differences in pelvic carriage; a larger sample might resolve this enigma even with the same measuring techniques. Of course there would be easier methods of measuring pelvic tilt if it were not done under competitive conditions.

As was noted in the author's 1976 study, the strains were again predominately to hamstrings of the left leg. Both the 1976 study and this one indicate strength differences which favor the muscles of the right thigh. Perhaps something so nominal as running around tracks counterclockwise contributes to an asymmetry that may precipitate hamstring strains.

CONCLUSIONS

On the basis of the data examined, the following characteristics appear to be important factors relative to precluding hamstring strains in sprinters. These characteristics include having:

1. bilaterality relative to hamstring and quadricep strength development,
2. "optimum" strength ratios between ipsilateral antagonists throughout the range of movement,
3. above "normal" hip-joint flexibility.

In all likelihood there are other factors too which may singly or synergistically be potentiators of hamstring strains. Although the data analyzed did not indict pelvic tilt as a contributing factor of hamstring strains, the kinematic data examined suggest its potential.

## References Cited


1. American Medical Association. Standard Nomenclature of Athletic Injuries. Chicago: American Medical Association, 1966.

2. Bell, S. Personal conversation, October 10, 1976.

3. Burkett, L. N. "Causative factors in hamstring strains." Medicine and Science in Sports. 2:39-42, 1970.

4. Carlsoo, S. and Molbech, S. "The functions of certain two-joint muscles in a closed muscular chain." Acta Morphologica Neerlando-Scandinavica 6:377-386, 1966.

5. Clarke, H. H. Muscular Strength and Endurance in Man. Englewood Cliffs: Prentice-Hall, Inc. 1966.

6. International Standard Orthopaedic Measurements. Bourbon, Indiana: Orthopaedic Equipment Co., Ind., 1965.

7. Jones, R. E. "A kinematic interpretation of running and its relationship to hamstrings injury." Journal of Health, Physical Education, and Recreation. Vol. 41:83, 1970.

8. Kendall, H. O., Kendall, F. P., and Wadsworth, G. E. Muscles--Testing and Function. Baltimore: The Williams and Wilkins Co., 1971.

9. Klafs, C. E. and Arnheim, D. D. Modern Principles of Athletic Training. St. Louis: C. V. Mosby Co., 1973.

10. Klein, K. K. and Allman, F. L. The Knee in Sports. Austin: Pemberton Press, 1969.

11. Liemohn, W. P. and Hopkins, R. "Strength and flexibility in relation to hamstring strains." International Congress of Physical Activity Sciences. Quebec City, July, 1976.

12. Liemohn, W. P. "Factors related to hamstring strains." Journal of Sports Medicine and Physical Fitness. In press.

13. Ryan, A. J. Personal conversation, July 12, 1976.

14. Sills, F. D. "Anthropometry in relation to physical education," In Johnson and Buskirk (eds.), Science and Medicine of Exercise and Sport. New York: Harper and Row, 1974.

15. Slocum, D. B. and Bowerman, W. "The biomechanics of running." Clinical Orthopaedics. 23:39-45, 1962.

16. Slocum, D. B. and James, S. L. "Biomechanics of running." Journal of the American Medical Association. 205: 97-104, 1968.

TABLE 1. CONTRALATERAL STRENGTH RATIOS

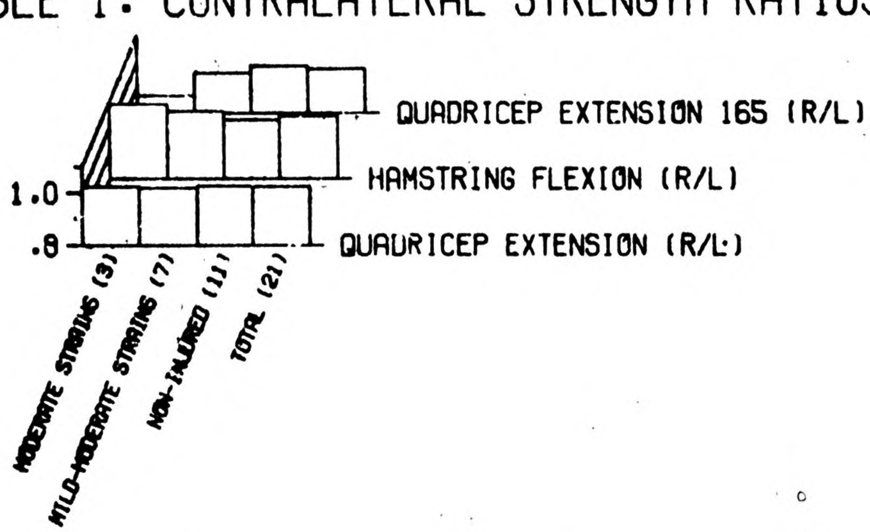



TABLE 2. IPSILATERAL STRENGTH RATIOS

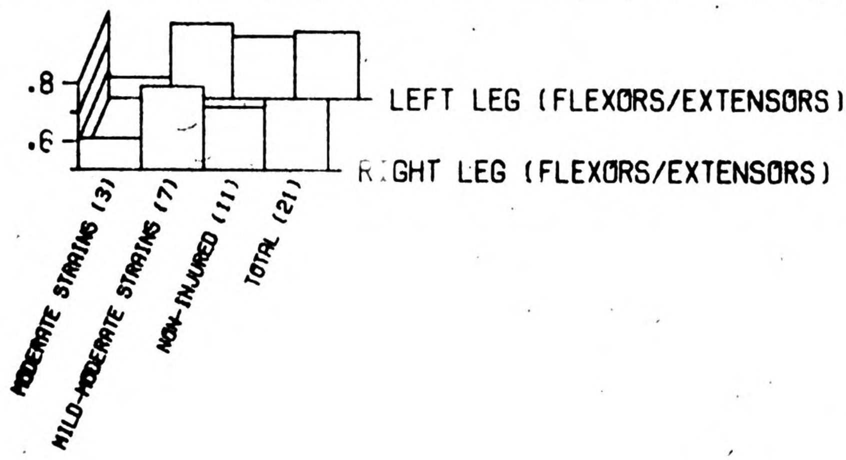
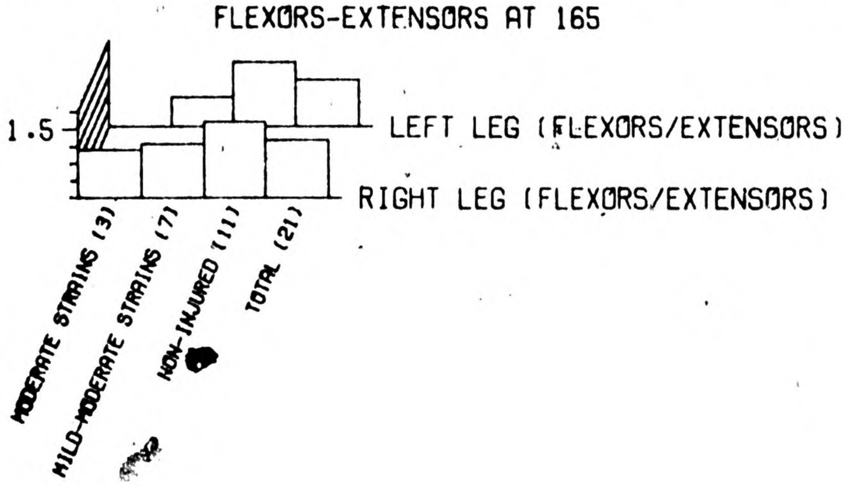
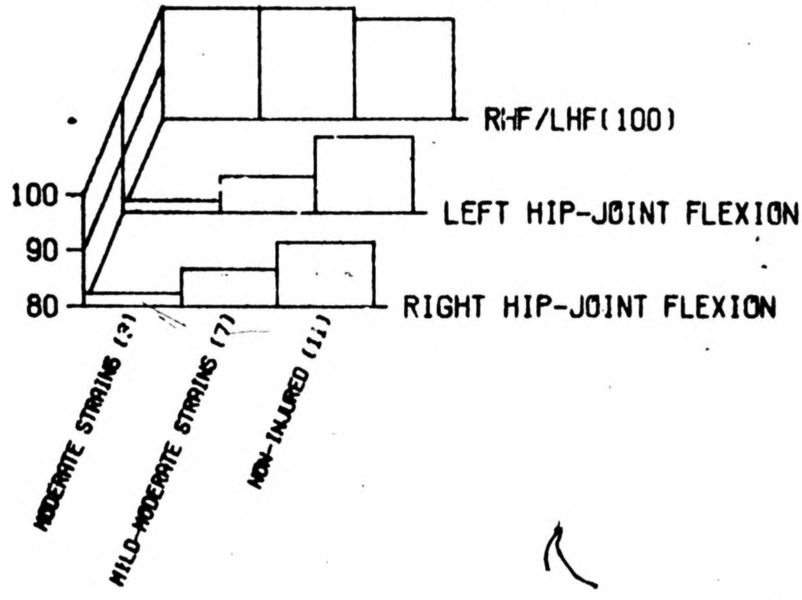


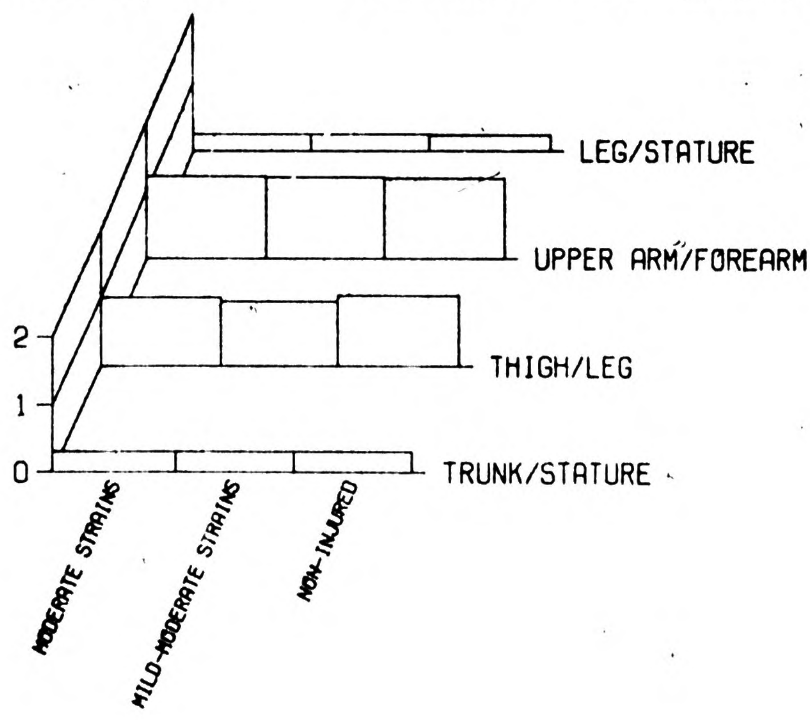

TABLE 3. IPSILATERAL STRENGTH RATIOS
FLEXORS-EXTENSORS AT 165



# TABLE 4. FLEXIBILITY COMPARISONS

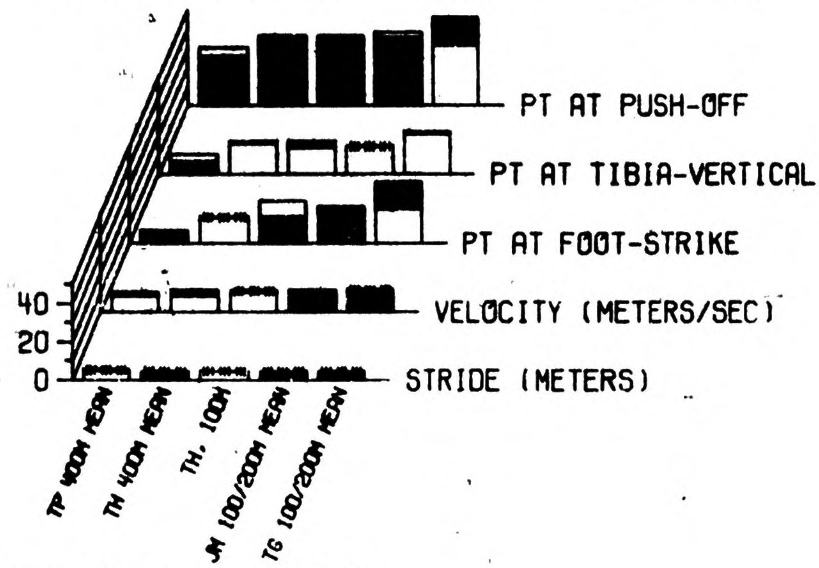



# TABLE 5. ANTHROPOMETRIC RATIOS



## TABLE 6. KINEMATIC DATA

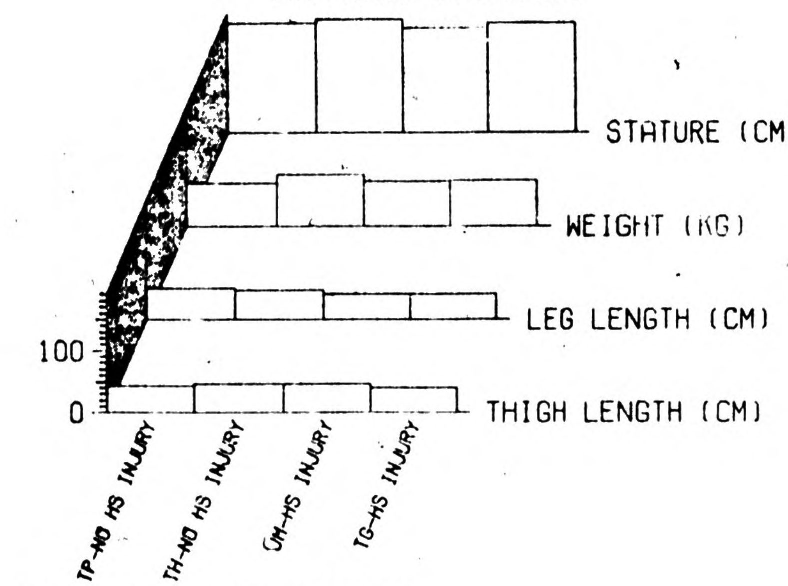
STRIDE/VELOCITY/PELVIC TILT (PT)




PRACTICE PERFORMANCE SHADED

## TABLE 7. MARKER VARIABLES

ANTHROPOMETRIC




HAMSTRING INJURY HISTORY